Radioecological and geochemical situation in the north-west of the Kola peninsula

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Abstract. *The scope of the paper is the current radioecological and geochemical situation in the north-west of Kola Peninsula. Study of ecological and geochemical environment in this area is an important task because of the high concentration of potential and existing sources of pollution here. The intensity of the environmental situation is caused mainly by the activity of radiation-dangerous objects. One of such enterprises is the ship reparation yard "Nerpa" specializing in the disposal of decommissioned nuclear submarines of the Russian Federation Navy since 1992. The purpose of the study is to analyze the anthropogenic impacts of nuclear industry on the landscapes of the northern territories on the example of the northwest Kola Peninsula. The area is located on the territory of the South-tundra acidic landscapes.*

1. INTRODUCTION

The studies were conducted within a radius of 50 km of «Nerpa». The ship-repairing plant is located on the western shore of the Kola Bay, to the north of Murmansk, in the tundra and the forest-tundra of natural areas. The landscape of the region due to the alternation of folded-block uplifts and depressions is shaped by the tectonic movements of the geological units, the erosional activity of the glaciers and repeated fluctuations of the sea level. The relief plays an important part in the redistribution of falling pollutants from the atmosphere including radionuclides. Soil cover is quite different but humic-illuvial podzols are dominated in forest-tundra, tundra humus podzolic soil and podbury are dominated mostly at the north and on the coastal area [1] The atmospheric circulation is the result of the monsoon: in the winter it is dominated by south-western winds from the mainland; in the summer – by the winds of the north-east of the Barents Sea [3].

2. MATERIALS AND METHODS

The present research is based on the teachings of the basic geochemical landscapes in the presentation of Prof. B. Polynov developed by Prof. A. Perelman and Prof. M. Glazovskaya [2,5]. Landscape-geochemical mapping is executed at researched area, the results are represented as a 1:20 000 scale landscape map of Nerpa area and geochemical map of the north-west coast of the Kola Bay of 1:200 000 scale. Autonomous and subordinate geochemical landscapes are estimated for the both maps on the base of analysis of geological and geomorphologic conditions, absolute and relative heights and hydro net features the hydro net features. Prevailing situation in the autonomous

landscapes which are not influenced by neighboring subordinate landscapes may be considered as an indicator of evaluation of the amount of radiation-chemical pollutants entering in atmosphere from natural landscapes.

2.1 Sampling procedures

The main method to field research was landscape geochemical catenary grading with detailed sampling all elementary landscapes. Autonomous landscapes were sampling in order to determine the zone of influence shipyard "Nerpa" of the environmental. The samples were selected from all available vertices in different distance from the plant. To determine the characteristics of the ^{137}Cs and HM vertical distribution in each sampling point several sections were made and samples of all genetic horizons were taken. About 650 soil samples were taken at 301 points during 2006-2009.

Selected samples were analyzed for the content of ^{137}Cs and natural radionuclides (^{40}K, ^{226}Ra, ^{232}Th) (analyst A.Kerzin, IGEM RAS). The measurements were carried out at scintillation ɣ-ray spectrometer (detector - NaJ (Tl) 160 × 160 mm × 55 wells with 110 mm). Concentrations of stable pollutants like S, As, V, Cu, Ni, Co, Zn, Pb, and some other elements in samples were determined. The measurements were carried out at XRF WD Spectrometer Philips PW2400 (analyst A.Yakushev, IGEM RAS).

3. RESULTS AND CONCLUSIONS

The peat soils with the highest content of organic substance are characterized by the lower levels of HM in comparison with podzols and podburs but they are more sensitive to contamination, as evidenced by the presence of spatial trends (Tab.1).

Table1. The background content of ^{137}Cs and heavy metals

Soil type	^{137}Cs Bq/kg	Heavy metals mg/kg						
		Cr	V	Co	Ni	Cu	Zn	Pb
Podburs	32,2	50,08	55,13	7,63	24,93	20,94	42,41	9,68
Peat soils	44,7	31,64	35,18	5,21	19,62	18,34	27,88	6,08
Podzols	42,1	61,50	62,28	5,83	17,99	13,56	42,85	8,45

The processes of lateral redistribution of ^{137}Cs and heavy metals in soils of the investigated area are mild, as indicated by low values of the lateral differentiation (L = 0,5-1,5) of the listed above elements in soils. The lateral differentiation of ^{137}Cs and HM more contrast is manifested in the organic horizon, which is proved by the significant fluctuations in the value L - from 0,04 to 1,85. For the subordinate landscapes it is characterized by a more intensive removal of ^{137}Cs and HM from the soil profile in comparison with stand-alone ones (Tab.2).

Table 2. Differentiation of catena soils by the content of ^{137}Cs and heavy metals

Characteristics	Geochemical landscapes					
	Autonomous	Transeluvial1	Transeluvial2	Transaccumulative	Transeluvia3	Superaqual
Organic horizons						
L (Cr)	1	0,04	0,56	0,11	0,09	0,03
L (Co)	1	0,11	0,90	0,47	0,62	0,10
L (Ni)	1	0,41	1,36	0,62	0,47	0,34
L (Zn)	1	0,97	1,42	0,56	0,51	0,55
L(Cs-137)	1	0,26	0,25	0,70	1,25	0,87
pH	4,1	4,00	3,80	3,60	4,10	4,10
Average of soil profile						
L (Cr)	1	0,69	0,92	0,43	0,67	0,13
L (Co)	1	0,58	0,68	0,42	0,55	0,08
L (Ni)	1	0,59	0,79	0,34	0,53	0,11
L (Zn)	1	0,67	0,89	0,35	0,52	0,10
L(Cs-137)	1	0,82	1,85	0,34	0,36	0,43
pH	4,1	4,50	5,00	5,10	4,80	4,96

The analysis of the radial differentiation of the gross forms of HM has shown the predominance of eluvial type of profile distribution in all three types of soil. This is due to metal leaching from the upper rich one in the organic substance and a more acidic part of the profile and accumulation in the lower horizons of the alkaline barrier. The increasing of acidity leads to the mobility of ^{137}Cs and many of HM, which becomes the result of their removal from the upper soil profile. This pattern is broken in podzols for Pb and Cu, which have an accumulative type of the radial distribution, due to less acidic environment, which reduces the mobility of organo-mineral compounds of these metals and does not form an alkali barrier. Gleying leads to a decrease in the mobility of ^{137}Cs and heavy metals in soils due to the presence of alkaline and reductive geochemical barriers (Tab. 3).

Table 3. Dependence of the content of heavy metals on alkali-acid conditions of environment (on an example of podzol profile)

Soil horizons	HM content (mg/kg)							*pH*	*Gum us*
	Cr	V	Co	Ni	Cu	Zn	Pb		
A0	53	76	5	26	18	69	19	*3,2*	*36,5*
A2	50	71	4	22	15	63	12	*4,4*	*0,64*
Bf	57	64	5	25	14	36	17	*5,1*	*2,69*
Bh	82	81	16	39	27	53	18	*5,4*	*1,38*

The ecological state of soils in the north-west of the Kola Peninsula is rated as satisfactory. The average content of ^{137}Cs in the soil reaches approximately 7% of the maximum permissible concentration for the Russian Federation. The zone of influence of «Nerpa» on the environment by ^{137}Cs is identified at a distance of 15-17 km from the plant industrial area [4].

In most of the studied sections MPC of heavy metals were found, only Cr and Co were recorded in excess of 15 and 14% of cases, respectively. This suggests that the contamination of soil V, Pb, Ni, Cu in the studied area is absent, and Cr, Co, Zn are a little. In the north-western direction one can see an increased concentration of HM away from the plant. This is due to the presence of contamination from the plant “Pechenganickel” and local sources of HM.

4. SUMMARY

According to the analysis of the data on the content of radioactive cesium and heavy metals (HM) there has been assessed an ecological and geochemical state of soils in the north-west of the Kola Peninsula. It is established that the average concentrations of metals in the shipyard «Nerpa» are substantially below the maximum allowable quantity. By the nature of the distribution of ^{137}Cs and heavy metals there is defined a border zone of the influence of the plant on the main soil types.

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